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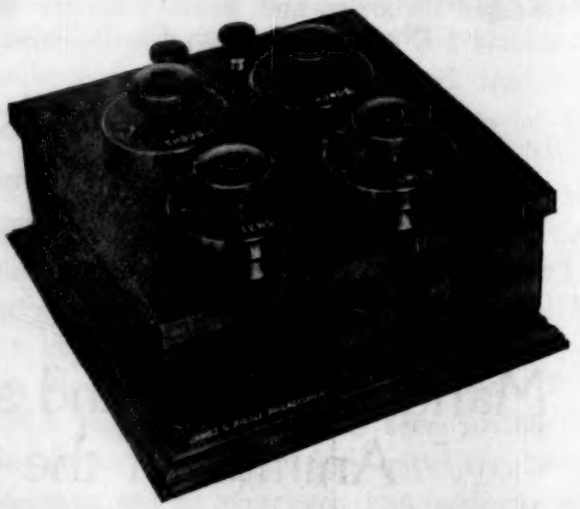

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SEVENTY-FIVE YEARS OF AMERICAN GEOLOGY[1]

As we commemorate the seventy-fifth anniversary of the American Association for the Advancement of Science, it is a pleasure to recall that this association sprang from the Association of American Geologists and Naturalists, that that association grew from the Association of American Geologists, and that that association in turn was initiated by a call from the Board of Geologists in control of the Geological Survey of New York. This evolution occupied a decade or more just previous to 1848, the date of the founding of this association. It may be convenient to think of the epoch we commemorate roundly as the latter half of the last century and the first quarter of the present century. I hasten to ask forgiveness beforehand for many shortcomings. The record is too rich to be compassed in an hour. A multitude of events of real importance must be passed without mention and those mentioned must be treated too briefly. I can only jump from peak to peak. I hope I shall have your sanction—or if not your pardon—for two general omissions, all formal attempt to give personal credit—which would require a volume—and all effort to pass judgment on questions about which our profession differs, though I shall endeavor to make clear such differences. One of the leading features of our memorial epoch is the extent to which unsettled questions have been developed and the earnestness with which we are struggling with them.

I. THE INCREASE OF GEOLOGICAL LITERATURE

If we could bring to mind a picture of the best geological library in America in 1848 and could realize at the moment all geologic values it contained and the stage of science it represented and could then also bring to mind and full realization the best geological library in America to-day, the contrast would go far to give a true measure of the progress of our science during the seventy-five years. This can only be done very imperfectly in imagination, but the thought may help toward the reality.

II. PROGRESS IN AREAL EXTENSION; GEOLOGIC SURVEYS

In the 30's and 40's of the last century, the establishment of state geological surveys followed one an-

[1] An address before the Section of Geology and Geography on December 28, 1923, the Seventy-fifth Anniversary of the American Association for the Advancement of Science.

other so rapidly as to be dubbed an epidemic, but yet, in spite of this enthusiasm, at the time this association was inaugurated not more than a third of the United States, and a much smaller fraction of the Continent, was geologically known even in a preliminary way. The recent geologic map of Willis perhaps best shows at a glance the status to-day. The contrast is very great. There has been a grand accomplishment. In its way, it is not likely to be surpassed in the future.

At the outset the leadership in surveys was taken by the states and provinces; there was no organized national survey. National geological work began early, but chiefly by the attachment of geologists to expeditions organized for other purposes. Then followed special surveys of growing importance, but more than one third of our memorial epoch had passed before a comprehensive national survey was established. Even the state surveys of the earlier decades were commonly authorized for short periods only. "Complete" surveys of tens of thousands of square miles, with full reports thereon, were ordered made in four or five years, or some such time, on the basis of a few thousand dollars appropriated to cover expenses. It certainly would not be safe to say that "*complete*" surveys were the result, but heroic things were done in the endeavor to meet the requirement. Later, but tardily, the need for continuous surveys was recognized; the dream of completeness became a thing of the past.

III. Extension of the Geologic Column

Great extension in area has been matched by great extension in depth. At the opening of the epoch we celebrate, the geologic column was made to embrace the "Primary," which was simply the cooled crust of a molten globe, igneous and lifeless, and the "Secondary," "Tertiary," and "Quaternary," which were chiefly series of bedded sediments deposited on the "crust." At that time these were supopsed to be separated by catastrophic disruptions which destroyed all previous life and led to repeopling by newly created life. The great unconformities were interpreted as the relics of sweeping catastrophies, not, as now, merely gaps represented by deposition elsewhere.

As time went on, the breaks in the column were reduced by the recognition of equivalent beds deposited elsewhere. Catastrophic speed and violence were gradually replaced by slow and quiet action. The doctrine called, rather inaccurately, uniformitarianism was brought across the Atlantic and naturalized in part, but given a saner interpretation. Hall, Dana, Logan and other Americans seem to have been more influential by their personal leadership than by their qualified adoption of the imported doctrine. In truth, of course, it was Nature's record in building this continent that led the movement. The American record is unsurpassed as a geologic instructor.

Not only was the upper, more obviously stratigraphic, column thus made longer and more continuous, but there was a significant extension downward. The Cambrian beds had been taken as the definite and logical base of the sedimentary series. In the last half of our epoch, however, terrane after terrane, more or less sedimentary, were found to lie geologically below the Cambrian. The thickness of these sub-added beds is now commonly estimated as rising to an order equal to the whole column above the Cambrian, and, what is equally significant, the lower end is yet to be found. Thus, at the end of our seventy-five year epoch, the stratigraphic column is interpreted as several times as long as at the beginning, with a likelihood that it will grow still further by the filling in of a multitude of small gaps, not at first noticed, and by further extension downward.

Not only has the length of the geologic column grown greatly, but profound changes of view as to its nature have taken place. The sharp division into two parts, a lifeless igneous base and a sedimentary fossiliferous superstructure, has given place to the general concept of continuity with merely minor oscillations in the times and regions of major activity. Life has been traced much below the Cambrian, but its lower record is very imperfect. The recent discoveries of more ample and varied life in the lower Paleozoic, particularly the Cambrian, implies, under current evolutional philosophy, a very great downward extension of life. In the judgment of some biologists and geologists, this extension probably reaches below all the pre-Cambrian terranes as yet recognized, though this pre-Cambrian extension is great. The "Azoic" bottom has retired to depths unknown. This profoundly changes the life aspect of the column.

On the physical side, it is now recognized by field workers on the lower horizons that sediments, pyroclastics and lava-flows—all these being surface deposits—enter into the make-up of six or eight thick terranes below the Cambrian. At the same time, great igneous masses, once supposed to be basal, are now found to be intrusions into these surficial and more or less sedimentary accumulations and hence incidents of the stratigraphic series. In the upper part of the column, on the other hand, similar great batholiths have been found to be intrusive into formations as late as the Mesozoic and Cenozoic, while the surficial lava floods of these later formations sometimes rival those of the pre-Cambrian terranes. Naturally, metamorphism has gone farthest in the older and more deeply buried terranes, especially where greater pressure, heat and time have been brought into cooperation, and this tends to maintain the inherited view, but discounting the changes due to metamorphism, the differences between the upper and lower

parts of the column seem to most geologists much less contrasted than they appeared 75 years ago.

IV. New Concepts of Available Time

The extension of the geologic column and the decline of interpretation by swift catastrophic action, together with the increased acceptance of evolutionary views of the life, led geologists during the last half of the last century to postulate greater and greater lapses of time because they seemed necessary to explain satisfactorily the expanding geologic record. The greatness of this extension drew forth protests from distinguished physicists, astronomers and mathematicians, who urged reasons which seemed to them very cogent why available geologic time was limited to shorter lapses by other cosmic processes on which it was dependent. There arose a memorable contest too well known to need deployment here. It is sufficient to note that the restrictive argument was given great weight during the last half of the last century, and led to strained interpretations of geological phenomena. The recent discoveries of the prodigious energies concealed in the constitution of matter, however, have dissipated these hampering views. Geological interpretation is now free to follow geologic evidence. Not only that: radio-activity has furnished a line of specific evidence that seems to directly imply as high antiquity of the lowermost rocks as perhaps either geologic or biologic interpretation requires.

V. Increased Knowledge of the Combinations of Earth Substances

Knowledge of the material of the earth has been very greatly increased by the thousands of chemical analyses that have been made, in increasing numbers, as the epoch has progressed. These have been gathered into convenient and suggestive form in Clarke's "Data of geochemistry." In addition to their own inherent value, these form a firm basis for the mineralogic, petrologic and economic phases of geology, all of which are intimately related to the chemical.

One of the earliest and most notable treatises on the composition and mineralogic organization of earth substance was the great work of Dana, supplemented by that of his son. The influence of these works has been more than simply American.

A little before the middle of our memorial epoch, the use of transmitted light through thin slices of rock opened a new vista into the intimate structure of minerals and rocks, and inaugurated a new petrologic era. The far-reaching nature of this illumination is difficult to measure; fortunately, it is so well known that I need not try to emphasize it here. While the initiation of this was foreign rather than American, it was promptly naturalized and America soon began to make returns in kind.

The happy thought of Laue that the systematic arrangement of atoms in the surfaces of crystals might serve as a diffraction grating opened a still more penetrating vista into the structure of crystals and has given a tangible picture of the openness and orderliness of the lattice arrangement of atoms in crystals, and suggests the trend of all probable primary material arrangements in the domain next above that of the molecule.

One of the most significant penetrations into the composition and mode of formation of rocks has been gained by a study of the differentiation of magmas as they are passing by stages into the solid state. The complementary action which presumably takes place when magmas are being generated from mixed material has been recognized but not as yet much developed.

VI. Light on the Constitution of Matter

Through the researches of chemists and physicists, geologists are now permitted to participate in a most profound insight into the constitution of matter. This is an opportunity of the utmost importance to geology. Most of our inherited concepts of earth substance took shape from the inherited notion that the ultimate integer of matter was an infinitely hard, incompressible, indivisible atom. Out of this there arose false notions of absolute rigidity and incompressibility in compacted compounds of atoms. We are now presented with a picture of opposite import. The atom is now held to be a revolutional mechanism of a singularly open kind, compressible to an extent whose limit is unknown and at present indeterminable, and withal elastic to a marvelous degree. Its intense revolutions seem to give it gyroscopic stability of an extraordinary degree, while its powerful electric and magnetic fields and polarities seem to give the fixity of attachment which is the essence of rigidity. Thus, the very atoms and the closer combinations of atoms (molecules and crystals) seem to define with great clearness the fundamental structure of earth substance. In these fundamental structural types there is fixity of attachment at a given point, or in a given position or attitude, of one integer to another, accompanied by an elastic factor, which permits yielding within the elastic limits but tends to restore the integers to their previous relations, *i.e.*, the elastico-rigid state. This state of fixed or rigid attachment of the integers to given points or in given positions or attitudes is to be distinguished from indifferent attachment of the adhesive sticky or viscous sort which permits motion proportional to the stress but has no elastic or restorative factor. The atomic studies seem further to make it clear that all these qualities have dynamic sources and hence are variable in proportion to the dynamic agencies that give rise to them. The technical factor "rigidity" seems to be simply the

strength of the fixed attachments, subject to elastic yield to the elastic limit, beyond which the structure either breaks down or is transformed into a new or modified elastico-rigid structure. If heat or other dispersive agencies force the atoms or molecules beyond the limits of these intimate attachments, unfixed attachments of the viscous type seem to ensue. Thus, a clearer vision of the intimate nature of earth-substance offers itself for the acceptance of geologists.

But, important as is this substitution of an open dynamic mechanism in place of the incompressible, indivisible atom of former concepts, this is not the limit of revolutionary things offered geologists for election or rejection. It is now held that all atoms above hydrogen are composite. As some of them are now undergoing spontaneous disintegration, there arises the general question whether others or even all the composite atoms are not subject to transformation into other atoms under some of the present conditions within the cosmos, and whether more or less of these conditions may not exist within the earth. This opens very widely the door of assignable reorganizations already urged by the newer school of diastrophists. Apparently, geologists must now face the possibility, if not the probability, that the atoms within the earth may undergo transformations much more widely than present evidences demonstrate, and that this may include constructive transformations as well as destructive ones.

It is significant that even the atomic transformations, so far as known, do not involve any general catastrophe to the mineral affected. They are brought about by individual actions on the part of the constituent integers, one following another at intervals while the embracing structure remains well organized and, to ordinary sense, unmodified. There seems no ground for doubt that in the disintegration of uranium, thorium and the other spontaneously transforming minerals, the action is idioatomic in the sense that the changes take place atom by atom individually and according to the special nature of each. This is in close analogy to the view held by one school of geologists respecting changes in glaciers, metamorphosing rock undergoing "flow," and elastico-rigid material in general, under conditions favorable for this class of motion or deformation, technically grouped under the term "idiomolecular action." When such idiomolecular transformations pervade massive bodies, the general effect takes on the outward semblance of *flow* and is called "flow," but it is not a miscellaneous, pell-mell movement of all the constituent integers, as is liquid flow; it is really a reconstructive process stimulated by stress and carried out by individual atomic or molecular action. The movement of glaciers is interpreted by one school of glaciologists as due to such idiomolecular reconstruction. So, likewise, one school of metamorphologists interpret "rock flow" as belonging to the same category. At the same time, it has long been known that crystals may be so affected by heat or other agencies that they pass into a fluid state and deform in fluidal fashion attended with viscous resistance, and lose their elastico-rigid properties. So also it is familiar knowledge that crystals may be so stressed as to break down by fracture, granulation or shear. Thus, even before the revolutionary discoveries of the constitution of matter, geologists were face to face with antithetical interpretations of flow and other intimate changes of form and texture. This diversity of interpretation calls into function some of the least familiar, most subtle and most radical considerations which affect the problems of the earth body. These we pass on to the tender mercies of the next epoch.

VII. Dominance of Revolutional Energy over Vibratory Energy

The revolutional insight into the fundamental mechanism of earth substance involves a scarcely less revolutional view of the phases of energy embodied in the earth. Seventy-five years ago the vibratory forms of energy—particularly heat—almost monopolized geologic thought respecting the earth's evolution. Heat inherited from the cosmological state and heat produced by compression were thought to dominate the early history of the earth and to control the state of its interior at all later times. Revolutional energy was little recognized except in problems affected by the rotation of the earth. Now, if the new views of the constitution of matter are accepted, the ratio is profoundly reversed. The revolutional energy embodied in the earth may be safely said to be many hundreds of thousands of times as great as the vibratory energy. More than this, the revolutional energy is found to be an essential factor in the constitution of matter and is thus much more fundamental in its nature. The vibratory energy seems to arise mainly from the inevitable collisions, compressions, frictions, interferences or maladjustments of some kind between the organized mechanisms in the pursuit of their individual courses. It seems to take on the aspect of a derivative form of energy growing incidentally out of conflicts rather than an orderly constitutional form of energy. It is rather significant that the constructional form of energy is so unobtrusive that it has taken an inquiring race all the thousands of years of its history, until yesterday, to discover even its existence. The energies that take form from conflict and interference have always been obvious enough. (There is a text for a sermon here, but it doesn't belong to my story.) The geologic importance of this phase of the new disclosures lies in the fact that revolutional energy is peculiarly the energy of organization, is scarcely less than the organizing factor itself, while vibratory energy is domi-

nantly the energy of disorganization and dissipation. We are, therefore, invited to consider whether continuous organization and reorganization of the earth substance is not one of the greatest of geologic processes, and whether it does not go on without end in the sense that other cosmic processes do. This would mean that the interior heat of the earth is, in part at least, a product of the earth's internal metamorphisms, some of which are exothermic and some endothermic—oftenest perhaps a partition between the two. It would follow from this that there is going on within the earth even now, as for ages past, mutual transformations of revolutional and vibratory activity into one another with a result which is a trend toward equilibrium and nearer an equation than the verge of a catastrophe.

VIII. Contributions of Cosmology to the Constitution of the Earth

While I hold that the origin of the earth is a geological question (however much it may also be a question in several other sciences) and a question of unsurpassed geological moment, I here defer to those who take a more restricted view of the scope of geology and shall dwell only on the phases that lead to inferences of strictly geological aspect.

During the earlier part of our memorial epoch, almost all views of earth genesis postulated some form of concentration of diffuse material by self-gravitation. It was held that the inevitable loss of heat led to increased rotation and this in turn to the separation of planetary matter. The most common view was that the earth passed from a gaseous (or equivalent) state to a liquid state which later crusted over. There remained differences of view as to how far the interior solidified. From any form of a fluidal view there arises logically the doctrine that the earth material segregated into concentric shells in the order of specific gravity, the heavier toward the center, the lighter toward the surface. This should have given a state of perfect isostasy, in a horizontal as well as vertical sense. How the later inequalities arose from such a homogeneous start remains an outstanding problem.

Considered in a broad general way, the working factor in this type of evolution is in the concentrating mass itself; the planets arise simply as its own offspring; they were parthenogenic, as a zoologist would say, or monoecious, as a botanist would say, or, let us say, mono-parental. The evolution, in all its main essentials, sprang from the energy and material of the parent nebula and was essentially a process of concentration, partition and reorganization.

Rather late in our memorial epoch, a dioecious or bi-parental hypothesis of origin was developed, stimulated by the feeling that none of the monoecious hypotheses could meet the combination of the peculiar dynamical features found in the solar system. This dioecious (planetesimal) hypothesis postulated the dynamic cooperation of the sun and a passing star (or its equivalent), the latter contributing the surplus energy and rotatory momentum unassignable to the sun-system alone. This greater energy and momentum took form as a scattered planetesimal condition of the constituent matter from which aggregation into the planets, planetoids and satellites pursued a natural but very slow process, so that the great heat generated by the aggregating process was largely lost as the process went on, while the earth remained relatively cool, the material also remaining highly mixed. This feature is the point of greatest geologic divergence from the preceding views. Such a mixed state of solid particles, at the outset, implies a long series of later reorganizations, segregations and metamorphisms, with little likelihood that these are yet complete. It is quite obvious that the evolution of such a cold mainly solid accretional earth must depart rather radically from that of the older gaseo-molten earth.

IX. Progress in Structural and Diastrophic Views

At the opening of the epoch under review, a single simple structural concept of the earth, as a whole, occupied the field almost exclusively, that of a solid crust floating on a mobile substratum, with a deeper interior which had at least once been molten and either still remained so or had solidified under pressure in part or in whole. It was supposed that some molten matter was intruded into and through the crust; that the primitive atmosphere originally held and later precipitated its overburden of waters upon the crust as it cooled and formed a universal ocean. Out of this almost ideal symmetry it was held that progressive cooling gave rise to deformation, one of the first effects of which was the emergence of land, and following this emergence, the era of erosion and deposit began.

In the first decades of our epoch, the main battle of views lay between catastrophic modes of action and modes that came to be called, with some inaccuracy, uniformitarian. At first catastrophism seems to have been more declared than uniformitarianism, but as time went on geologists in increasing numbers turned to the latter view and catastrophism slowly lost its dominance, but has never yet entirely disappeared.

The doctrine of the permanency of continents and ocean basins arose rather early in our epoch and, under the leadership of Dana, became a widely accepted American doctrine. It is to be noted, however, that there has been some retrogression from this view in recent years, notably in the acceptance of the rather free reversals in land and sea postulated by

the Neumayr-Suess school, and the revived postulation of the shifting of continents and the wandering of the poles.

It was perfectly logical that views of diastrophism built upon the concept of a cooling, molten globe should take on certain distinct features, such as shallowness of deformation, since only a relatively thin crust could reasonably be supposed to be involved in the effects of surface cooling. So, too, starting with a molten state of the whole substance in which viscous coherence was the prevailing phase of molecular aggregation, it was natural that viscousness should be extended to the solid state when evidence to the contrary was not outstanding.

On the other hand, the concepts of diastrophism built on the accretional theory, having to deal mainly with mixed heterogeneous materials, at the start—and later with the only partially assorted products brought about by changes in these—naturally assumed greater depth of diastrophism, for it is to be presumed that as the internal stresses were increased by accessions and progress in concentration, they would give rise to further though less diastrophism, whatever their depth. Logically, therefore, no specific limit to the depth of diastrophism is postulated. Under this concept there is naturally also a larger recognition of the elastico-rigid state, as distinguished from the visco-solid state. The deeper internal deformations are referred more largely to glacier-like flow or rock-flow of the type that attends metamorphic reorganization.

The contest between views of diastrophism based on the concept of a visco-solid state and on the concept of an elastico-solid state is another of those subtle deep-lying issues which this epoch passes on to the next.

X. Discoveries that have changed the Aspect of Diastrophism

The discovery that radioactivity is a persistent source of heat and that there are enough radioactive heaters in a thin outer shell to compensate for all the known radiation of heat from the earth's surface has put a new aspect on the doctrine of secular cooling as a source of diastrophism. It raises the serious question whether there has been any material reduction in the earth's temperature since Proterozoic times.

The transmission through the earth-body of seismic waves along paths that traverse depths equal to half of its radius and more, is accepted by most seismologists as indicating that a solid-elastic state prevails at least to these depths, *i.e.*, prevails in seven eighths of the volume of the earth-body. As to the central one eighth, the status is less sure and it remains for improved instruments and increased skill to test the deeper penetrations, if indeed they really succeed in traversing these longer and deeper chords. Recent investigations of the body tides and nutations imply a very effective elastic solidity of the earth-body, as a whole, and so presumably of its central one eighth. These discoveries relative to the state of the main mass are held to bear decisively on the vital question whether the material involved in diastrophism is elastically solid (elastico-rigid) or viscously solid. A viscous adhesion of the molecules to one another with no elastic throw-back is held by one school at least to be fatal to the transmission of the second set of preliminary seismic waves in the manner and at the velocities recorded. So also, the increasing density of the interior as depth increases in itself tends to retard the velocity of the waves. And yet, in spite of all increases of density and all viscousness, the velocity of the waves increases notably with increase of depth in the outer portion and less notably below, but when correction is made for the probable increase of density, the record continues to imply increase of elastic solidity as far as the record is interpretable.

The special theories of diastrophism are such a host that I must pass them without even mention.

XI. Progress in Views of Vulcanism

The concept of vulcanism most prevalent at the birth of our association placed its seat and source in the postulated molten mass beneath the "crust." The concept was a natural derivative from the gaseo-molten cosmology then prevalent. Since an actual fluidal connection between the volcanic neck and the molten interior was commonly held, and since this should logically have been made manifest by tidal oscillations and simultaneous eruptions in adjacent volcanoes, much effort was made to detect the indicated movements, but the results were disappointing. An unexpected degree of independence was found, though minor sympathetic effects assignable to common body stresses have been detected. The trend of recent opinion has hence set toward the view that volcanic action is local and arises from special local causes. It is worthy of note that this trend has been led by inquirers who favor the gaseo-molten theory of earth genesis, while such local origin and independence is the logical inference under the accretional theory, a notable case of convergence.

XII. Advances in Views of Metamorphism

In the early stages of our memorial period, it was supposed that nearly all rocks below the Cambrian were igneous, and metamorphic changes in these received scant attention. Metamorphism at that stage was little more than a transformation of sediments and the sediments were relatively limited. In late

years, both the range and the importance of metamorphism have greatly increased.

This holds true measurably without regard to views of the primitive state of the earth material, but under the view that the earth grew up slowly by accessions of all kinds of matter in a solid state, metamorphism logically rises to a place of commanding importance. On such mixed solid material metamorphic action should have begun at once, wherever it took place, thus preceding vulcanism—and should equally have followed it. If the earth was solid throughout its known eras, metamorphism should have continued with more or less, but probably declining activity, to the present day.

Since metamorphic changes have an endothermic as well as an exothermic phase, metamorphism plays a radical part in problems of the earth's internal temperature. The status of the internal temperature of the earth is thus made to depend on the progressive consumption as well as production of heat, and not so much on inherited heat.

Through the density and stress changes attending metamorphism, it becomes a factor in diastrophism. Reorganization in the depths of the earth, as well as in its shell, is held by a growing school of geologists to be a source of diastrophism.

XIII. Progress in Erosional and Sedimentary Geology

However the deformations of the earth were caused and renewed at intervals, they were prerequisites to the erosion and deposition that have taken place, and hence have been given precedence here. The successive diastrophisms determined the special phases of stratigraphic work, while they influenced also the course of life evolution.

The early interpretations of stratigraphic processes were strongly tinged with catastrophism. There was great freedom in postulating not only rises and falls of the crust, but great debacles of strangely fantastic types. But these excessive liberties with the laws of nature were rather individual than representative of the rising school of American geologists.

It is historically worth while to note that alternations of relative quiescence and disturbance and the rhythmical play of erosion and deposition were early recognized and emphasized.

About the middle of our memorial epoch, the very important doctrine of base-leveling was given form and started on its career by Powell and Gilbert. This doctrine, carried into fuller detail and application by others later, has powerfully affected the interpretation of the larger aspects of denudation and deposition, as also of life progress, and has had an indirect influence on problems of megadiastrophism.

An adequate appreciation of subaerial deposits belongs almost wholly to recent years, as also the distinctive functions of epicontinental and abyssal seas. The facility with which deposition on slopes gives elusive suggestion of great crustal sinking has been urged but is yet to be fully realized and used as a check on extravagant assignments of depression.

Recently, two tenets whose mutual incompatibility does not seem to have been generally recognized, have made notable progress: (1) the doctrine of isostasy, which, in its very nature, tends to keep light segments in the high places and heavy segments in the low places—a special kind of permanency, especially in a solid earth—and (2) the postulation of great reversals of land and sea, involving eversions of the heavy oceanic segments and submersions of the lighter continental segments—an imported mode of interpretation following Neumayr and Suess. Ancestrally, the first is the offspring of a "floating crust," the second of the catastrophism of the earlier days, but both have been modified to escape the burden of their inheritances. Both must be reckoned among the notable movements in American geology which pass on into the next epoch.

XIV. Progress in Correlation by the Life Record

It is scarcely possible for those who have not lived through the whole of our memorial epoch to realize the profundity of the change between its beginning and end in the interpretation of the life record. Well into the early years of the epoch it was taught in our standard text-books that successive creations of life followed successive catastrophies which detroyed all existing life. I was taught specifically, and with some followed successive catastrophies which destroyed all life was destroyed; not a single species passed from the Paleozoic to the Mesozoic. I was taught that there were similar complete destructions later. Perhaps this tells the status of geological *knowledge* as well as geologic thought at the beginning of our epoch as pointedly as anything can. The doctrine of continuous life development—which of course meant also continous conditions congenial to life—had to face as stiff an opposition as ever stood in the way of a scientific concept. And yet none has ever won a more signal triumph in the scientific world or wrought a more profound reversal of interpretation. This issue in the American geological world was fought out mainly in the middle third of the 75 years we celebrate.

It was fortunate indeed for American science that the states which led in geologic mapping and correlation were seated on geologic terranes built with more than usual fullness and symmetry, especially

New York. It was equally fortunate that their fossil records were clear and decisive. The influence of New York and the adjacent regions and of the able geologists and paleontologists who worked these fields was a boon to our science of the first order. It was likewise fortunate that the Paleozoic series of the adjacent interior had an unsurpassed symmetry and fullness of development and that its correlation fell into like able hands. By reason of its inherent superiority and of the personal ability of its workers, the American system of correlation and classification has had a development of its own, save that the larger groupings, assumed to represent worldwide stages, have largely been adapted from the earlier European classifications. In most respects the American continent is better suited than most other continents to serve as a historical standard, both because of the greatness of its terranes and the steadiness of its growth. From the very first, a commanding series of paleontological contributions came from the students of the Paleozoic series of the eastern region, and later a singularly brilliant series of contributions were poured in by the workers on the later terranes of the great West. The record of American paleontology and stratigraphy is one which may well give eminent satisfaction to the people of our continent.

XV. Progress in Hydrospheric Geology

The evolution of the much branched tree of life implies continuity in the conditions hospitable to life, not only in general, but in special adaptation to each independent branch of life after it left its parent branch. This implies an evolution of the land suited to the support of land life and an evolution of the ocean suited to support the marine life. At no time since an existing branch started its independent evolution can we rationally suppose that its requisite environment has been wholly destroyed. Thus suitable physical continuity is implied by organic evolution. Catastrophism had a fair field so long as new creations were available to repeople the devastated regions, but it at once became hampered as soon as the concept of continuity of life was accepted. And yet it is one of the seeming paradoxes of the history of geology that catastrophism, particularly in the hidden depths of the sea, is freely called into service by one school of geologists to explain the geographic gaps in certain regional successions of life, while to another school it seems to be one of the historical idiosyncrasies of the current epoch that tenets which have a catastrophic aspect linger almost solely in the dark shadows of the deep seas.

In the early part of our epoch the sea was simply the sea. There was little distinction of parts or of functions; it rose and fell; it came and went; and little thought was given to the how or the why. But in time both the dynamics and the deposits of the sea began to be scrutinized. Continental shelves and epicontinental seas were differentiated from the abyssal oceans; their respective deposits were discriminated. It came to be recognized that the continental shelves and the beds of the epicontinental seas are *parts of the continents,* not properly parts of the ocean basins. This recognition gives to the continental terranes about one third of the shell of the earth and to the sub-oceanic segments about two thirds. This gives a new aspect to the working factors of the elevation-depression land-sea problem. The geologic records of the later ages—which alone are fairly complete—seem to show that the continents have gone up together and the ocean basins have gone down together—an indication of earth dynamics of no little moment.

At the opening of the association's history, there was scarcely any dissent from the view that the waters of the ocean were precipitated from the supposed hot moist atmosphere as soon as the radiation of primitive heat permitted it, and that water action on the rock surface then began and has continued ever since. At the start the levelness of the cooled crust was supposed to have given rise to a universal ocean, but as inequalities arose the waters were gathered into the deeper basins, the land appeared, disintegration and solution took place, the solutes were carried to the ocean, and the ocean grew more and more saline as time went on. On the basis of this concept, its most typical salt, sodium chloride, has been held to give data for an estimate of the earth's age.

It was only late in our epoch that these tenets were called in question on the ground that the whole mass of the ocean could not have been held in the air as vapor under the kinetic theory of gases. In harmony with this was the postulate that the hydrosphere has grown gradually by accretion through the ages. This rivalry of views is one of the late issues of our epoch, and the battle of the waters and of the brininess of the great deep is another of the conflicts of geological thought that must pass on into the next epoch.

XVI. Advances in Atmospheric Geology

In the early days of our epoch, the vast hot vaporous atmosphere of the older view was a fruitful theme for geologic eloquence. It is almost a pity that the kinetic theory of gases has pushed this flow of eloquence off the stage. It was later seen that the steady evolution of life of types intimately dependent on a certain range of temperature and on an atmosphere suitable for breathing imposed severe restrictions on postulates respecting the early atmospheres and climates. It also came to be seen that mechanical restrictions had been imposed from the beginning by the limited ability of the earth's gravity to hold gases of such molecular activities as those that constitute the

atmosphere. These were among the considerations that led to the later view that the atmosphere gathered gradually; partly from without and partly from within, but always under the joint control of gravity and its own molecular activity. The logic of the kinetic theory of gases leads to the conclusion that the atmosphere grades upward from its intensely collisional state at the bottom into a much more open state in which outward vaulting and return of the molecules is more characteristic than direct to-and-fro collision. In turn, this vaulting or krenal atmosphere is held to pass into a still more attenuated state in which satellite-like revolutions of molecules become characteristic, forming an orbital ultra-atmosphere. This reaches to the limit of the earth's sphere of control. The new picture is that of an envelope of three intergrading phases enwrapping the planet. Thus enwrapped, the earth revolves through the outlying ultra-atmospheres of the sun, giving rise to interchanges between the ultra-atmospheres of the earth and of the sun. This interchange works constantly toward equilibrium between the two atmospheres. This last concept implies atmospheric persistence and measurable constancy—save for relatively small oscillations—throughout the known part of geologic history. This view has but lately come upon the stage and adds another to the list of issues that pass on into the next epoch.

XVII. The Trends of Views on Geologic Climates

As previously noted, the inherited view of the origin of the earth implied a hot moist atmosphere thick with perpetual clouds, forming a dull sultry climate. This was commonly supposed to have continued until the luxuriant vegetation of the Carboniferous period "purified" the air of its supposed excess of carbon-dioxide and permitted the appearance of air-breathing life. What was then regarded as the first appearance of annual rings in the trunks of trees was held to be telling evidence of a passage from a dull uniform cloudy climate into one of diverse seasons glorified by sunshine. The growing evidences of the past 75 years, however, have forced very radical departures from this familiar view. Glacial deposits have been found as far back as the Proterozoic, and arid stages at least as far back as the Cambrian. In Carboniferous times it would seem that the sunshine was strong enough to give rise to protective palisade cells in the upper layer of the leaves. Air-breathing animals are now known to have flourished earlier than the Carboniferous.

Between the ancient glacial stages, warm climates extending far within the polar circles are implied by fossil evidence. These apparently continued longer, even in the polar regions, than the glacial stages. The evidence thus seems to many geologists, probably to most, to indicate that cold climates have alternated with warm climates, and dry climates with wet climates, from the earliest well-recorded times to the present. Some would press the picture further and postulate an approximately uniform chain of oscillating swings of climate from one limit to the opposite, forming a climatic rhythm running from the beginning of the legible geologic record to the present. Some connect the climatic rhythm with the diastrophic and other rhythms which they interpret as marking the earth's progress. But others question some of these tenets.

Climatic explanations are as plenty as blackberries in the woods; we can not stop to even count them. For the glacial phase, they are certainly enough to make glad the heart of the protagonist of the method of multiple working hypotheses, but it is not so clear that they shed luster upon it.

XVIII. The Progress of Prognosis

One can not well recall the great climatic descensus from a hot wet beginning to a cold dry end—that held the stage in the early part of our epoch—without seeing how inevitable was the forecast of a further descent to a final winter and a universal desert. And one can not wonder that such eloquence as was left over from the dramatic beginning was poured forth in prophecy of the dismal end lying just a little in front of us.

In strong contrast is the later prognosis which forecasts a future of merely oscillating conditions, like those of the past, extending on to limits we dare not set, to lapses perhaps as great as the past. At least this view sees no signs of a definite decline to an early end. A final winter seems no more foreshadowed by the recent glacial stages than it was by the Proterozoic glaciations. The aridities of to-day seem no more definitely to imply a universal desert than did the arid state of India in Cambrian times, or the wide-ranging Permo-Triassic aridities in their day. Probably an end must come. But if 60,000 suns can live long enough to gather into a globular cluster by a mode which perhaps took ten billion years or some such time, we may feel with some confidence that our sun will do its part to keep the earth alive for eras in the future not unlike those in the past. At least one of the new rival views that we hand over to the future permits us to think that man's future career is chiefly a matter of his own making. We may, then, rationally regard the study of the earth's existing resources, as well as the development of man's capacities to use them in making the most of himself, as one of the potential factors in his own destiny.

T. C. Chamberlin

University of Chicago

THE OPPORTUNITY OF THE SECTION ON MEDICAL SCIENCES[1]

ON this occasion of the seventy-fifth anniversary of the founding of the American Association for the Advancement of Science it seems appropriate for us to put our house in order and consider what measures may be taken to promote a more effective affiliation between the medical profession and this great body of scientists. The Section on Medical Sciences is a comparatively recent creation, but its immediate predecessor, the Section on Physiology and Experimental Medicine, was formed in 1901, and enough experience has been had to enable us to determine the value of a medical section and to define some of the problems which confront it. What is the outstanding function of the section? What contribution is it making to the medical profession, and what contribution is it making to the association as a whole? Unless we are satisfied that the section can perform a distinctive service towards the advancement of science, and unless we feel clear that such service is being given, it is certainly our duty to alter the character of these meetings, or, indeed, to do away with them entirely.

Scientific societies are essentially instruments designed for the dissemination of knowledge and for the support or extension of our system of scientific research. Like books, journals and laboratories, they are tools to be preserved as long as they serve a useful purpose, but when they fail in this purpose they should be destroyed to make room for more efficient apparatus or reconstructed to meet new needs. At the present time the medical sciences are in the midst of a period of expansion, and the extensive development of medical research goes hand in hand with the founding of new societies and journals designed to fill the requirements of highly specialized interests. We have reached a stage when no one can cope with medical literature as a whole and many of us fail in the struggle to keep abreast with what is published even in limited fields. This promotion of new journals and new societies is as natural as it is necessary during the periods when rapid advance is being made at special points along the frontier of knowledge, and at such times they serve an important function, but once the line of progress becomes stabilized their character tends to deteriorate and they may cease to have an adequate reason for existence. It happens, perhaps unfortunately, that more interest is manifested in creating new societies and journals than in stopping them, and the result is that many are allowed to degenerate into a dry senility when euthanasia might have cut short an honorable career. If the body of our journals and societies is to remain manageable and serviceable those that are outworn and serve no immediate function must be rehabilitated or else completely discarded to make room for new societies and new journals to meet new needs.

At the present time, in addition to purely local societies, the medical profession gives active support to, and, therefore, presumably derives benefit from, two types of association, the membership of which has wide geographical distribution. The first of these is the large general society represented by the American Medical Association and to a lesser degree by the state medical societies and such affiliations as the Tri-State Medical Association and the Pacific Northwest Medical Association. The meetings of these bodies are attended by great numbers of practitioners and the papers are in the nature of broad presentations of subjects of practical importance. The second type of association consists of the small societies of investigators in special fields, and in their meetings topics of distinctly limited interest are presented and discussed. These two types of society account for approximately all the time that medical men can devote to such meetings, and the needs of the profession are adequately filled by the strictly medical associations already in existence. Any other organization, therefore, which would gain the support of the medical profession must be prepared to make a wholly different and an extraordinarily forcible appeal.

Where, in such a system, does the Section on Medical Sciences of this association fit? If one is to judge from the support it has received from the medical profession in recent years, we must admit that it seems to have very little place. In spite of the exertions of our devoted secretary and in spite of excellent programs, the attendance of medical men has been discouragingly small. It is true that a large number of medical practitioners and medical scientists are enrolled in the association, but this appears to be due to a desire for affiliation with the general objects of the association, and to an appreciation of the journals published by the association. Attendance at meetings has not, as yet, been to them an important part of membership, and it is such active support that must eventually be the test of success.

If this is a just appraisal of the situation, are we to conclude that our society can serve no important purpose and that our wisest course of action is to cease striving to keep it alive? As a matter of fact, I believe that a more careful consideration indicates exactly the contrary conclusion. The reason that the section has not yet made any general appeal to the medical profession is unquestionably because it has seemed to offer little that is not covered by other more widely known societies, but the actual outstanding and undeniable fact is that by virtue of its relation to the association as a whole the Section on Medical Sciences is in a position to give medical men

[1] Address of the vice-president and chairman of Section N—Medical Sciences—American Association for the Advancement of Science, December 29, 1923.

something that they can not obtain anywhere else. This section has no need to enter the field as a rival of other existing societies and it should not attempt to duplicate their activities, for it is happily possessed of the possibility of making a wholly distinct and unique contribution to American medicine. This unusual opportunity depends on the fact that the American Association provides a common ground on which medical men can meet their fellow-workers in other branches of science. Now it happens that never in its history has there been such vital need for medicine to strengthen its bonds with the so-called fundamental sciences, for at no time has the trend of medical research demonstrated more clearly its final dependence on these sciences. It is only a few years, for example, since the medical investigator seemed well prepared to attack the problems of metabolism if he were fortified by a background of general biological chemistry, but his successor of to-day often finds it necessary to turn to physical chemistry, to electrochemistry, to photochemistry and to the various branches of physics. In the use of these sciences the medical investigator may be forced to go entirely outside of the ranks of his own profession and seek the cooperation of experts whose experience has never brought them into contact with the field of medicine. Many of the possible linkings between medicine and what a comparatively short time ago seemed to be wholly unrelated sciences are already becoming evident to us; and no one can foretell what other unexpected affiliations may soon become desirable. It is the opportunity to strengthen and to develop these relationships that is offered by the American Association for the Advancement of Science, for its meetings draw together the foremost representatives of the various branches of science, and there, if only for a moment, we may be sure of their assistance, suggestion and criticism. Advantage has already been taken of this relationship, but it is easy to conceive how our medical programs would be still further illuminated, and the scope of the discussion broadened by the contributions of members of the sections of physics, chemistry, engineering, zoology, botany, anthropology and psychology, social and economic sciences and agriculture. The advantages of such a relationship, moreover, would not be entirely on one side, for many of those who came to help us would return to their special work with the stimulation which necessarily comes from the realization of the community of scientific thought.

The strategic position of the Section on Medical Sciences offers such an opportunity for making a distinct contribution to medicine, by promoting a closer intercourse between medical men and their fellow-scientists, that every effort should be made to overcome the practical difficulties that now stand in the way of its further development. One explanation of the failure of medical men to attend the meetings may be found in the fact that it has seemed advisable not to undertake more than a short meeting with a single symposium at each session, and members can hardly be expected to travel considerable distances to attend so brief a meeting. A more serious consideration, however, is the fact that many of the special societies of medical scientists, the membership of which includes exactly the type of men most likely to appreciate the opportunities offered by combined meetings under the auspices of the association, hold their own sessions at the same time but frequently at a different place. The best method, therefore, for the development of the Section on Medical Sciences would seem to be to induce these special societies to meet at the same time and place as the association, and to combine, under the association, in a single session at which the dominant feature would be the discussion of subjects of mutual interest by eminent members of the non-medical sections. An attempt has already been made to bring this about, but it has not yet met with success. Many difficulties present themselves, not the least of which is the already overloaded program of many of the special societies. The only way to overcome these difficulties is to indicate more forcibly the advantages which may be anticipated from a many-sided consideration of medical problems. If it can be demonstrated that the Section on Medical Sciences does not aim to duplicate the work of any existing society, but that it has within it that which enables it to make an entirely distinct and a much needed contribution to medicine, its ultimate success would seem to be assured. The development of a closer relationship with the other sections would not only make the Section on Medical Sciences assume an important place in the medical profession, but would fulfil its larger function towards the American Association for the Advancement of Science.

FRANCIS W. PEABODY

BOSTON CITY HOSPITAL

DMITRI NIKOLAYEVICH ANUCHIN

RUSSIAN science has sustained a severe loss in the recent death of Professor Dmitri Nikolayevich Anuchin of the Moscow University. The family of Russian scientists becomes ever smaller. Many of them are obliged to live abroad and quite a few have perished in the last few years from privation or under even more tragic circumstances.

Professor Anuchin was born in 1843. In 1867 he was graduated from Moscow University. Originally he specialized in zoology, but he soon became interested in anthropology, prehistoric archeology and geography. After several years' study in the universities of England, France, Germany and Italy, he was appointed professor of anthropology, when for

the first time the chair of anthropology was founded (in 1880) in the University of Moscow. He lectured also on ethnology and geography in the university and on archeology in the Moscow Archeological Institute.

During his long career as a teacher Professor Anuchin trained several generations of well known specialists in different lines of anthropology and related sciences as tutors, writers and explorers. It would take too much space to enumerate their names. The same may be said concerning his scientific publications, they would form a library in themselves. For about half a century he was president of the Moscow (former Imperial) Society for Advancement of Natural Sciences, Anthropology and Ethnography and chairman of the Anthropological and Geographical Divisions of the Society. He was the editor of the memoirs of the society and of the anthropological and geographical journals of the corresponding divisions. He was elected fellow of the Academy of Sciences of Russia and received the degree of doctor *honoris causa* from several foreign universities.

Professor Anuchin was not only a prominent scientist, but was also actively interested in the political and public life of his country. For many years he was connected with the liberal and most popular daily paper in Russia the "Russkiya Vedomosty" as one of its publishers, editors and contributors.

He was for many years a widower and several years ago he lost his favorite son. In spite of the privations during the years following the Bolshevist revolution and his advanced age he preserved his working faculties and continued his activities as teacher and scientist. I saw him in 1921 when visiting Moscow. He lived in an unheated attic, was badly clothed and subsisted on the poor ration given to scientists by the Soviet government. He finally succumbed and died last summer after a short illness.

WALDEMAR JOCHELSON

SCIENTIFIC EVENTS

THE HISTORY OF SCIENCE SOCIETY

A GROUP of scientific men selected from a large number of those who are interested in the history of science state that it is desirable to organize a society for the encouragement of the study of the subject and for the assurance of the permanency and the adequate financial support of the international publication *Isis*, now so ably edited by Dr. George Sarton.

This periodical is devoted to the history of science in its broadest aspect and has, for the past few years, been published by the editor under circumstances that would have deterred most other men. The first five volumes, in which some ninety scholars collaborated, contain 3,116 pages, 70 papers, 527 reviews, and 9,196 bibliographic notes relative to the various aspects of the history and philosophy of the several sciences. The subscription price is six dollars a year, but it is proposed to place the annual dues of the society at five dollars, to make *Isis* the official journal, and to send it gratis to members. Those who participate in the work of the society will assist in advancing the general cause in which they are interested, they will encourage the work of Section L of the American Association for the Advancement of Science, and they will aid in maintaining and in assuring the future of a journal that is recognized at home and abroad as a powerful factor in stimulating the study of the history of science.

Although the world has so many societies of various kinds that a new one may seem superfluous, nevertheless the support of *Isis* (which can not at present be accomplished in any other way that seems open), joined to a movement in which many scholars are interested and to which Dr. Sarton is devoting his life, affords an opportunity which it is believed will be welcomed in the Americas and elsewhere. Indeed, the hope which has been expressed of an endowment for *Isis* can probably be realized only in case there is an organization of this kind to assure interest in the undertaking.

It may also be observed that the proposed society will be the first, on any large scale, to afford a common meeting ground for scientists, historians and philosophers. Indeed, the study of the history of science seems to provide the only feasible method for bridging the widening gap between the men of science on the one hand and the men of letters on the other.

In case the number of foundation members warrants the organizing committee in proceeding, it is proposed that it elect a president, two vice-presidents, a secretary, a treasurer and a council, the latter to consist of colleagues in the society who are interested in the history of science in general and of the several sciences in particular and to represent as wide a geographic distribution as possible. These officers and council members will then be asked to perfect the organization by preparing a constitution, to formally elect the foundation members, to arrange for the immediate continuance of *Isis*, and to serve during the calendar year of 1924.

Correspondence may, for the present, be addressed to Professor David Eugene Smith, 525 West 120th St., New York City.

THE NATIONAL CONFERENCE ON PHARMACEUTICAL RESEARCH

THE National Conference on Pharmaceutical Research is now fully organized with ten main committees designed to transact its most important business.

The members of the several committees are representatives of the following national organizations: American Conference of Pharmaceutical Faculties, American Drug Manufacturers' Association, American Pharmaceutical Association, American Pharmaceutical Manufacturers' Association, Bureau of Chemistry, U. S. Department of Agriculture, National Association of Boards of Pharmacy, National Association of Retail Druggists, the Proprietary Association and the U. S. P. Revision Committee. Other national associations have been invited to join and when they enter the Research Conference their representatives will be assigned positions upon appropriate committees. As to the personnel of the ten committees, we find in the list given below professors of pharmacy, pharmaceutical chemistry and pharmaceutical botany, retail pharmacists, chemists and botanists in pharmaceutical manufacturing plants and governmental scientists. Geographically the committees include scientists from Massachusetts to Oregon and from Minnesota to North Carolina.

The ten committees follow:

Dispensing Pharmacy: G. M. Beringer, Chairman; J. A. Koch and E. R. Selzer.

Manufacture of U. S. P. and N. F. Galenicals: E. F. Cook, Chairman; W. L. Scoville and William Kaminski.

Standardization of U. S. P. and N. F. Galenicals: W. L. Scoville, Chairman; Louis Emanuel, G. A. Kinsel, C. H. LaWall, J. P. Snyder and W. H. Zeigler.

Manufacture of Medicinal Chemicals: H. A. B. Dunning, Chairman; C. J. Balliet and E. B. Carter.

Standardization of Medicinal Chemicals: C. H. LaWall, Chairman; E. B. Carter, W. O. Emery, B. L. Murray and Joseph Rosin.

Sources and Identification of Botanic Drugs: H. W. Youngken, Chairman; D. E. Combs, W. O. Emery, Henry Kramer, Albert Schneider and H. M. Whelpley.

Standardization of Botanic Drugs: E. L. Newcomb, Chairman; G. D. Beal, W. O. Emery, E. N. Gathercoal and S. B. Penick.

Chemistry of Drug Plants: W. O. Emery, Chairman; D. E. Combs, F. W. Heyl, Arno Viehoever.

Biological Products: Reid Hunt, Chairman; W. O. Emery, A. D. Holmes and P. A. Pittenger.

Business Research in Pharmacy: A. Hunsberger, Chairman; H. C. Christensen, J. A. Koch and A. W. Pauley.

THE GEOLOGICAL SOCIETY OF AMERICA

THE thirty-sixth annual meeting of the Geological Society of America was held in Washington, D. C., from December 27 to 29, at the invitation of the Geological Society of Washington. Both the Paleontological Society and the Mineralogical Society of America held meetings at the same time, and all were held in the building of the Department of the Interior.

The attendance was larger than usual, more than 400 persons being registered. Seventy-three scientific papers were presented, covering a very wide range of titles.

The principal address, that of the retiring president, Mr. David White, was on "Gravity observations from the standpoint of local geology."

The list of officers for 1924 is as follows:

President: Waldemar Lindgren, Cambridge, Mass.

First Vice-president: William A. Parks, Toronto, Canada.

Second Vice-president: Johan A. Udden, Austin, Texas.

Third Vice-president: Edward W. Berry, Baltimore, Md.

Fourth Vice-president: Henry S. Washington, Washington, D. C.

Secretary: Charles P. Berkey, New York, N. Y.

Treasurer: Edward B. Mathews, Baltimore, Md.

Editor: J. Stanley-Brown, New York, N. Y.

Councilors: E. S. Bastin, Chicago, Ill.; L. G. Westgate, Delaware, Ohio; Edmund Otis Hovey, New York, N. Y.; Alfred H. Brooks, Washington, D. C.; Fred E. Wright, Washington, D. C.; William H. Twenhofel, Madison, Wisconsin.

In addition, six correspondents and 20 fellows were elected, making the total membership 507.

The next meeting of the society is to be held in Ithaca, N. Y., in December, 1924, as the guests of Cornell University.

CHARLES P. BERKEY,
Secretary

THE E. W. D. HOLWAY HERBARIUM AND LIBRARY

BOTANISTS who have been so fortunate as to know the zeal and discriminating care of the late E. W. D. Holway will be glad to learn that the University of Minnesota has undertaken to complete the *Uredineae*[1] by the publication of the fifth and last part. Collections made prior to his untimely death are being studied and will be published by specialists.

Professor Holway left his rich botanical library and herbarium—one of the largest of the rust herbaria in this country in number of species represented and a most valuable and unique asset for research—to the University of Minnesota. Arrangements are soon to be made whereby both the volumes and the sheets can be more readily consulted by specialists.

Mrs. Holway has presented the duplicate materials to the department of botany, and these are to be used primarily for purposes of exchange with a view to building up the original collection. The original herbarium will be closed so that no confusion concerning the specimens which have been studied by Mr. Holway may arise. Materials added in the future will be designated as a supplementary series.

The university is desirous of obtaining as nearly complete as possible the series of letters written by

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[1] Holway, E. W. D., "North American Uredineae," Vol. I, parts 1–4, Minneapolis, 1905–1913.

Mr. Holway for permanent preservation at the university. Those who have letters from Mr. Holway, or who are interested in his collections, are invited to write the undersigned.

J. Arthur Harris,
Cold Spring Harbor,
Long Island, N. Y.

THE MEDICAL SCHOOL OF THE UNIVERSITY OF ROCHESTER

It is planned to open the new medical school of the University of Rochester in September, 1925, and the Strong Memorial Hospital, with its 240 beds, will open a few weeks in advance, and the nurses' home four months earlier, in order that its training school may complete the training of an adequate staff of undergraduate nurses before the hospital first opens its doors to the public.

Considering 1925 as the year for the completion of the building program of the school, it is estimated that there will be available, from accumulated interest and the Strong Memorial gift, approximately $3,000,000 for building expenses, without encroaching upon the $9,000,000 capital originally donated. This fund will be left intact, therefore, as an endowment to provide for the running expenses of both school and hospital. As far as is known, this is one of the few instances on record where a large educational institution will have been built without encroaching upon its original endowments. It is announced that those entrusted with the destinies of the Rochester institution have chosen deliberately to build modestly and simply and to place the future reputation of the school in its scholastic attainments rather than in its outer appearance.

A final addition to the medical school and hospital group, as at present planned, will be the new municipal hospital to contain 240 beds to be built by the city of Rochester at some time in the near future close by the Strong Memorial Hospital, and coordinated with it both physically and in its operation. Piling already has been driven for the foundations of this structure.

It will be remembered that the General Education Board and George Eastman, of the Eastman Kodak Company, provided the sum of $9,000,000 for the foundation of a medical school for the University of Rochester. To this amount was added a donation of $1,000,000 from the two daughters of the late Henry A. Strong for a hosiptal to be built in conjunction with the school in order to enable it to carry out its work under the most favorable conditions.

SCIENTIFIC NOTES AND NEWS

J. S. Diller recently retired from the United States Geological Survey, in which he has served for more than forty years. In testimony of their esteem his associates on the survey tendered him a luncheon at the Cosmos Club on January 22, at which Colonel H. C. Rizer, chief clerk of the survey, presided. Dr. W. M. Davis, of Harvard University, a life-long friend of Mr. Diller, who was a guest at the luncheon, gave some reminiscences of their early experiences together in work on Appalachian structural geology. Appreciative remarks were made by Director George Otis Smith, Dr. F. W. Clarke and S. J. Kübel.

The seventieth birthday of Dr. Roux, director of the Pasteur Institute, was celebrated on December 17, in the library of the Pasteur Institute. Dr. Roux was present. M. Vallery-Radot and Dr. Calmette spoke on Roux's life and work.

Dr. Paul von Groth, professor of mineralogy in the University of Munich, whose eightieth birthday was celebrated on June 23, will retire on April 1.

Dr. Johannes Fibiger, professor ordinarius in pathologic anatomy at the University of Copenhagen, has been awarded the first Sofie A. Nordhoff-Jung Cancer Research Prize. The commission on award consisted of Professors Borst, Doederlein, v. Romberg and Sauerbruch, all of the University of Munich.

Frederick M. Becket, chief metallurgist of the Electro Metallurgical Company, and vice-president of the Union Carbide and Carbon Research Laboratories, Inc. (both subsidiaries of the Union Carbide and Carbon Corporation), was awarded the Perkin Medal of the Society of Chemical Industry, on January 11, for his achievements in the field of applied chemistry.

Officers of the Washington Academy of Sciences for 1924 are: *President:* Arthur L. Day, Geophysical Laboratory, Carnegie Institution; *corresponding secretary:* Francis B. Silsbee, Bureau of Standards; *recording secretary:* W. D. Lambert, U. S. Coast and Geodetic Survey; *treasurer:* R. L. Faris, U. S. Coast and Geodetic Survey.

Nathan Clifford Grover, chief hydraulic engineer of the United States Geological Survey, Washington, D. C., has been elected president of the Washington Society of Engineers.

William C. L. Eglin, vice-president in charge of the engineering department of the Philadelphia Electric Company, was installed as president of the Franklin Institute of the State of Pennsylvania on January 16.

William L. Saunders, chairman of the Naval Consulting Board, was elected on February 2 president of the United Engineering Society, New York City. Mr. Saunders is deputy chairman of the Federal Reserve Bank of New York, chairman of the Ingersoll-

Rand Company and a director of other large corporations. George H. Pegram, chief engineer of the Interborough lines, was elected first vice-president of the society and J. H. Renders, vice-president of the American Institute of Mining and Metallurgical Engineers, second vice-president. Alfred D. Flinn was chosen secretary, Joseph Struthers, treasurer, and Henry A. Lardner, assistant treasurer.

LOUIS A. OLNEY, professor of chemistry and dyeing at the Lowell Textile School, Lowell, Mass., was elected president of the American Association of Textile Chemists and Colorists at its annual meeting, held at Providence, R. I., December 8.

AT a recent meeting of the board of directors of the American Petroleum Institute the following officers were elected: *President,* Thomas A. O'Donnell; *vice-presidents,* R. D. Benson, Henry L. Doherty and J. W. Van Dyke; *Treasurer,* Harry F. Sinclair; *Secretary and counsel,* R. L. Welch.

DR. H. W. GILLETT has been appointed chief metallurgist of the Bureau of Standards, to succeed G. K. Burgess, who recently was promoted to the directorship. Dr. Gillett for a number of years has been engaged in work on alloys at the Ithaca section of the Bureau of Mines.

D. C. BARDWELL, a physical chemist on the staff of the Bureau of Mines, is being transferred from the Reno experiment station to the bureau's Washington office. He will continue his research work on rare metals.

W. H. WAGGAMAN has resigned as chemist of the Bureau of Soils to accept a position with the Victor Chemical Works, Chicago Heights, Ill., to take up phosphate and phosphoric acid investigations.

COLONEL J. H. FINNEY, of Washington; Professor Dugald C. Jackson, of the Massachusetts Institute of Technology; C. E. Skinner, of Pittsburgh, and F. B. Jewett and L. F. Morehouse, of New York, have been chosen to represent the American Institute of Electrical Engineers on the executive board of the American Engineering Council for the coming year.

A GRANT of $400 from the Bache Fund of the National Academy of Arts and Sciences has been made to Professor Harold Hibbert, Yale University, for the purchase of apparatus to be used for the determination of ultra-violet absorption spectra of compounds of interest in connection with the "Constitution and properties of carbohydrates and polysaccharides." An additional grant of $300 from the Cyrus M. Warren Fund has also been made for the purchase of apparatus and supplies in furtherance of this work.

THE Royal Society has made a grant of £100 from the Darwin fund to Dr. Margery Knight, of the Hartley Botanical Laboratories, for research on marine Algae at the Port Erin Marine Biological Station.

THE Carnegie Hero Fund trustees have awarded the honorary certificate and allowance of $375 a year to Reginald Blacknall, roentgenographer at the London Hospital, England, for twenty years, who, as the result of roentgen-ray work, contracted carcinoma, necessitating the amputation of both hands.

DR. D. E. DERRY, professor of anatomy at the Government Medical School in Cairo and a well-known anthropologist, has been charged with the examination of the mummy of Tut-ankh-amen.

H. H. MCKINNEY, plant pathologist in the Office of Cereal Investigations, U. S. Department of Agriculture, will spend the winter months at the School of Hygiene and Public Health of the Johns Hopkins University, conducting special investigations in connection with parasitic protozoa and the filterable virus diseases.

DR. ALICE M. BORING has been granted three years' leave of absence from Wellesley College to take charge of the department of biology of the University of Peking, China.

PROFESSOR GILBERT N. LEWIS, dean of the College of Chemistry of the University of California, has returned from a half year's vacation spent largely in the university towns of England. He gave a course of three lectures at Oxford University and a similar one at the University of London, both devoted to the theories of structure of atoms and molecules that he has developed.

WILLIAM MANSFIELD CLARK delivered a presidential address entitled "Life without oxygen" before the Chemical Society of Washington on January 10.

DR. EVARTS A. GRAHAM, professor of surgery, Washington University, School of Medicine, will deliver the fifth Harvey Society Lecture at the New York Academy of Medicine, on Saturday evening, February 9. His subject will be "Alterations of intrapleural pressure and their significance."

DR. LUDWIK SILBERSTEIN, of the Research Laboratory of the Eastman Kodak Company, gave three lectures before the faculty and students of McGill University on January 31 and February 1 and 2. The title of the lectures was "Radius of world curvature derived from spectrum shifts of distant celestial objects." The main result given and explained in these lectures was a set of consistent values of the world radius derived from seven globular clusters and the two magellanic clouds with a mean of 6.0×10^{12}

astronomical units, by means of a formula deduced by Dr. Silberstein from deSitter's relativistic cosmology.

THE University of Arizona announces a series of ten lectures on some phases of the chemistry of the simple sugars and the saccharinic acids by Dr. J. W. E. Glattfeld, of the University of Chicago. The lectures are being delivered during the present winter quarter which Dr. Glattfeld is spending in Tucson.

PROFESSOR STEPHEN S. VISHER, of Indiana University, lectured twice in January before the Geographic Society of Chicago on his recent trip to Pacific Islands and Australia.

DR. P. H. ROLFS delivered, on December 12, an address at the specially called meeting of the Sociedade Nacional de Agricultura, on the subject of "The Agricultural and Veterinary College of the State of Minas Geraes, and a System of Agricultural Colleges for Brazil."

THE Seabord Medical Society is negotiating to purchase the birthplace of the late Dr. Walter Reed, which will be maintained as a memorial. The old house in Gloucester County, Virginia, is in a dilapidated condition at the present time. In the spring of 1921 the Walter Reed Medical Society was organized as a memorial to Dr. Reed.

A SPECIAL meeting of the Berlin Microbiological Society was held on December 11, 1923, in commemoration of the eightieth anniversary of Koch's birth.

DR. EDWARD EMRYS-ROBERTS, professor of pathology and bacteriology in the University of Wales, died on January 17 at the age of forty-five years.

THE Fifth Congress of the International Union of Pure and Applied Chemistry will be held at Copenhagen from June 26 to July 1. American chemists who expect to attend the congress should send in their names to Dr. J. E. Zanetti, Chairman, Division of Chemistry and Chemical Technology, National Research Council, Washington, D. C.

THE fifty-seventh congress of the learned societies of Paris and the French Departments will be held at Dijon from April 22 to 26.

A MEETING of Swiss medical men was held at Berne in October, 1923, when the Swiss organizing committee was formed for an International Congress on Industrial Health. The first congress will be held at Geneva from July 18 to 20, and will deal with the following questions: Industrial lighting and eyestrain; impure air in factories; value of fatigue tests. The committee consists of Drs. von Gonzonbach, Silberschmidt, Zangger, Rossi, Carrière and Cristiani (chairman), and has headquarters at the Institut d'Hygiène, University of Geneva.

THE AMERICAN PHARMACEUTICAL ASSOCIATION has available a sum amounting to $450 which will be expended after October 1, 1924, for the encouragement of research. Investigators desiring financial aid in their work will communicate before March 1 with H. V. Arny, chairman, A. Ph. A. Research Committee, 115 West 68th St., New York, giving their past record and outlining the particular line of work for which the grant is desired.

THE following awards were made at the last meeting of the trustees of the Elizabeth Thompson Science Fund on November 27, 1923: To Hazeltine Stedman, Mt. Holyoke, $200 toward the purchase of equipment for an investigation on the effects of ultra violet radiation upon pure proteins; to Professor H. Stolyhwo, Anthropological Institute, Warsaw, $200 to aid in his studies of anthropologic types on Polish territory; to Dr. A. Anding, Gotha Observatory, Germany, $300 toward the continuation of investigations on the motion of the sun through space; to Dr. Israel Kleiner, N. Y. Homoeopathic Medical College, $100 for an investigation on the state of the sugar of the blood in normal diabetic human beings; to Dr. Wm. deB. MacNider, University of North Carolina, Medical Department, $285 for studying the effect of protecting the kidney against the injury from uranium nitrate by administering to dogs sodium bicarbonate. The Elizabeth Thompson Science Fund is administered by G. H. Parker, *president*; E. B. Wilson, *secretary*; Charles S. Rackemann, *treasurer*, and G. H. Baxter and W. B. Cannon, *members of the board of trustees*. The trustees meet three times a year toward the end of February, of May and of November. Applications should be in the hands of the secretary well in advance of the date of the meeting.

NINETEEN of the former students of Professor Carl H. Eigenmann, professor of zoology and dean of the graduate school of Indiana University, gave a dinner in his honor at the Hotel Gibson in Cincinnati, Ohio, during the convention of the American Association for the Advancement of Sicence. The students dated from more than thirty years ago to present classes. Those present were: Dr. Oscar Riddle and Dr. A. M. Banta, experimental zoologists from the Carnegie laboratory at Cold Spring Harbor; Dr. Chancey Juday, in charge of lake investigations, University of Wisconsin, Madison, Wisconsin; Dr. Clarence Kennedy, entomologist, Ohio State University; Dr. Frank H. Pike, professor of physiology, College of Physicians and Surgeons, New York City; Dr. Thomas J. Headlee, state entomologist, New Brunswick, New Jersey; Arthur W. Henn, curator of ichthyology, Carnegie

Museum, Pittsburgh, Pa.; Dr. Ira T. Wilson, professor of zoology, Heidelberg College, Tiffin, Ohio; Dr. O. P. Dellinger, professor of zoology, State Normal School, Pittsburg, Kansas; Dr. D. C. Warren, geneticist, Kansas State Agricultural College; Dr. Frank P. Reagan, professor of zoology, University of California; Dr. William Ray Allen, professor of zoology, University of Kentucky; Will P. Morgan, professor of zoology, Indiana Central College, Indianapolis, and the following from Indiana University: Dr. William J. Moenkhaus, professor of physiology; Dr. Will Scott, and Dr. Fernandus Payne, professors of zoology, and Nathan E. Pearson, Lowell T. Coggeshall, H. R. Bolen. Dr. Payne acted as toastmaster and Drs. Headlee, Riddle, Pike, Juday, Kennedy, Reagan, Banta, Scott and Eigenmann responded.

A STUDY of the reputed healing and medicinal properties of the hot springs situated on a government reserve at Hot Springs, Arkansas, will be one of the researches in cooperation with the United States government which the medical division of the National Research Council will consider this fall, according to Dr. Clarence M. Jackson, who is director of the medical division this year. Dr. Jackson is chairman of the department of anatomy in the school of medicine of the University of Minnesota, which has granted him a year's leave of absence. The investigations at Hot Springs have been requested by Dr. Hubert Work, secretary of the interior, who last year was president of the American Medical Association. During his year in Washington, Dr. Jackson plans to complete a book on "The Effects of Inanition" on which he is at work.

UNIVERSITY AND EDUCATIONAL NOTES

CONTRACTS have been awarded for the erection of the hall of chemistry for the University of West Virginia at Morgantown. It is estimated that the completed structure will cost about $750,000. The building will be 305.7 by 79 feet, four stories, basement and attic, with an extension of one story and basement.

DR. ELLIOT CARR CUTLER, associate in surgery and chairman in the department of surgery in the Harvard Medical School, has accepted the professorship of surgery in the School of Medicine at Western Reserve University and the office of house surgeon of Lakeside Hospital.

DR. GEORGE STRONG DERBY, formerly assistant professor of ophthalmology in the College of Physicians and Surgeons, Columbia University, has been appointed Williams professor of ophthalmology in place of Dr. Alexander Quackenboss who became professor emeritus on December 1.

DR. HOWARD DE FOREST, formerly assistant professor of botany at the University of Southern California, Los Angeles, has been promoted to a professorship of botany and to the chairmanship of the botany division of the department of biology.

DR. CHARLES SHATTUCK PALMER, National Research Council fellow in organic chemistry at Yale University, has accepted an appointment starting February first as assistant professor of organic chemistry at Northwestern University. He will have charge of the courses ordinarily given by Dr. W. Lee Lewis, who is on leave of absence from the university to serve as director of scientific research of the Institute of American Meat Packers.

DR. ARAO ITANO, assistant professor of microbiology at the Massachusetts Agricultural College, has tendered his resignation with the request that it take effect at the close of the current college year. He plans to return to Japan, where he is to have charge of the division of microbiology and chemistry at the Ohara Institute of Agricultural Research.

PROFESSOR ERNST MANGOLD, department head in the Physiological Institute in Freiberg, has been called to Berlin as director of the Veterinary Physiological Institute, to succeed the late Professor N. Zuntz.

DR. GANESH PRASAD, dean of the faculty of science in the Benares Hindu University, has been appointed Hardinge professor of higher mathematics in the University of Calcutta in succession to Professor C. E. Cullis.

DISCUSSION AND CORRESPONDENCE

MIRA, THE STRANGE STAR

A NOTE by *Science Service* in SCIENCE (Supplement, Dec. 28, 1923) on the significance of the recent discovery of a close companion to *Omicron Ceti* opens with the statement, which if correct would be disquieting, that the discovery "is baffling astronomers and may necessitate a revision of present theories of the size and distribution of the stars." This statement is expanded later in the note in the form of a dilemma. Either the two stars are physically connected, in which case the companion must be extraordinarily faint for a star of its spectral class; or they are independent and at entirely different orders of distance from us, in which case the companion, assuming it to have the luminosity of the average star of its class, must be "in a region of space where we know of no other star of this kind."

These statements seem to be based on an imperfect appreciation of the facts. In the first place the dilemma does not exist, for the annual proper motion of *Mira*, approximately 0.″23 in 186°, is in itself sufficient evidence of the physical connection of the two

stars. If the companion were an independent star, vastly more remote, it would almost certainly have no appreciable proper motion and the angular distance between it and *Mira* would therefore have been approximately 4″ in 1903, 7″ in 1890, and 10″ in 1877. At this distance it is at least improbable that it should have escaped detection by me in 1903 and it is incredible that it should have been overlooked by Burnham in the two earlier years. Still earlier the angular separation would have been greater, and the variable has been under observation for several centuries.

It follows that the companion is much fainter than the average star of its spectral class, but it does not follow that we may have to revise our theories of stellar size on this account. These are derived, in the sense of the statements under discussion, from the relations that have been established between luminosity and spectral class in what we may designate as normal stars, and can be applied only to such stars. Unquestionably, very nearly all the stars that have been brought under observation are normal, but there are a few exceptions. The companion to *Sirius* is one example, the double companion to 0^2 *Eridani* is another, the novae are especially in point. Apparently the companion to *Mira* is also an abnormal star, indeed, this might have been predicated simply from its association with such a star as *Mira*. As such it offers many interesting problems, but it does not affect our theories either of the size or of the distribution of the stars in general.

Robert G. Aitken

Lick Observatory

BOOKS FOR THE UNIVERSITY OF TOKYO

The recent burning of the great Library of the Imperial University of Tokyo (with 500,000 to 700,000 volumes) is in itself a world calamity. I learn that the American Universities, Law Schools and many City Libraries have given very generously of their publications and of duplicates. Much has also been received from private sources. The chief deficiencies, at present, are in scientific lines—medicine, physics, chemistry, biology, mathematics and engineering. At the request of Japanese friends, I make a special appeal to associations and workers in science for donations of books and serials of scientific value.

Shipments will be received and transported free at the following addresses:

Toyo Kisen Kaisha (T. Komatsu), 557 Market St., San Francisco, Cal.

Mr. Aneha, care Hopkins Company, 18 Old Slip, New York.

Nippon Yusen Kaisha, Colman Building, Seattle, Washington.

Osaka Shosen Kaisha, Steel Steamship Co., Whitney Building, New Orleans.

David Starr Jordan

RECLAIMING ALKALI SOILS

My attention has been called to a note published in a recent number of Science[1] in which reference is made to an experiment in applying alum to an alkali soil to improve its physical condition and its permeability to water. In this note the authors say:

"In connection with the study of treating alkali soils with sulfur several cultures were also made up applying alum at the rate of 40 tons of the crude material per acre as suggested by Scofield. The results seem to indicate that alum does not ameliorate the condition, since the colloids, after being precipitated, come back, leaving the soil practically in the same condition as in the checks."

In view of the fact that I have published some observations concerning the effect of aluminum sulphate on impermeable alkali soils, it might be inferred from the statement quoted that I had suggested the application of 40 tons of alum per acre and also that the beneficial effects of alum, if any, are very temporary and of no practical significance.

With respect to the first point, I do not recall having suggested that alum be used at the rate of 40 tons per acre. Since aluminum sulphate costs about $30 per ton f. o. b. factory, the land to be reclaimed by its use at the rate mentioned would have to be potentially very valuable to justify the expense. It is quite possible, however, that the authors quoted did not intend to imply that I had suggested this rate of application but merely that I had suggested the use of alum.

With respect to the second point, "that alum does not ameliorate the condition," it may be remarked that this does not seem strange if it was applied at the rate of 40 tons to two million pounds of soil which is to be inferred is what the authors regard as equivalent to an acre. The ratio of 40 tons to two million pounds is the same as the ratio of 4 to 100, in other words, the authors appear to have added 4 parts of alum to 100 parts of soil. The soil used is described as a sandy loam and it is probable that when saturated as for leaching it might hold 50 per cent. of water. The solution of 4 parts of alum in 50 parts of water would give a concentration of 8 per cent. in the soil solution and it would be a very alkaline soil that would neutralize the acidity of an 8 per cent. solution of alum.

As a matter of fact, a soil may be made impermeable to water by an excessive treatment with aluminum sulphate when it shows a strong acid reaction. With soils that are naturally neutral or slightly acid in reaction, a very light application of aluminum sulphate may induce impermeability. With alkaline soils, on the other hand, it has been found that the

[1] Joffe, J. S., and McLean, H. C., "The Biochemical Sulfur Oxidation as a Means of Improving Alkali Soils." Science, Vol. 58, p. 53, 1923.

use of aluminum sulphate in quantities sufficient to reduce the alkalinity nearly to the neutral point has resulted in marked improvement in the physical condition of the soil, particularly with respect to its permeability to water. This improvement in condition is certainly not temporary. With some soils that have been under observation for two years it still continues.

C. S. SCOFIELD
UNITED STATES DEPARTMENT OF AGRICULTURE

SIREN, A HERBIVOROUS SALAMANDER?

THE correlation of structure and habits is of great philosophical interest, and, if for correlation one read causation, of still greater interest. The study of form apart from function is a noted source of error, and the study of function apart from form, while not so productive of error, is frequently an unnoted waste of time.

These observations apply particularly well to the food preferences of Amphibians, which are in general comparable to the tolerably famous Ophidia of Iceland. In brief, Amphibians have no food preferences. Much careful work, very productive of negative results, has been done on the food of adult Salientia. These animals, as might be expected from their uniform dentition and digestive apparatus, are carnivorous and undiscriminating. What they eat is determined by its size and its propinquity. The food of the same species in different localities differs much more than does the food of different species in the same locality.

Larval Salientia differ considerably from adults in structure of mouth and of intestines, and in correlation with their long, convoluted digestive tract, their horny beaks and fringing rows of keratinous "teeth," they are herbivorous in the same fashion that the adults are carnivorous, and the food of tadpoles of different species is more alike than is the food of larva and adult of the same species.

Larval salamanders apparently do not differ in their food from adults, as is indicated by the similar structure of mouth and intestines in both. Nor do salamanders in general vary much from a uniform structure, or from an undiscriminating and carnivorous diet.

Siren and *Pseudobranchus*, of course, differ notably from the other salamanders in their mouth structures. Teeth are present only on the prevomers, and the dentary and the premaxilla are furnished with horny beaks, strangely reminiscent of those of tadpoles.

I had occasion recently to examine specimens of *Siren lacertina* from Gainesville, Florida. I found their stomachs and intestines packed with filamentous algae. The intestine was noticeably long and convoluted. Comparison with *Amphiuma*, a beast of similar shape and habitat, brought out a great difference in the proportionate lengths of the digestive tract. *Amphiuma* is carnivorous and the stomach of the specimen examined contained fragments of crawfish. The intestine extended almost straight through the body cavity and was of nearly the same length. The algae-crammed intestine of a *Siren* measured 1270 mm from mouth to anus, while the animal itself measured only 480 mm from mouth to anus.

Little has been published on the food of *Siren* from Linnaeus's original supposition that it ate serpents, to Hurter's remark, "Sirens feed on worms and minnows. Most of those in my possession were caught with hook and line baited with worms."[1]

Garman, indeed, says "LeConte found nothing but mud in the stomachs of those he examined."[2] This seems to be the only record of stomach examination, and the "mud" was very probably a black, semi-digested mass of algae.

Barton in his letter to Schneider in 1821 says that he fed his specimens on angleworms, pieces of meat, etc. This and Hurter's remarks may be compared with the well-known habits of tadpoles in aquaria, where they will eat decomposing animal matter, although their ordinary food is diatoms and algae.

E. R. DUNN
SMITH COLLEGE

SCIENTIFIC BOOKS

The Domain of Natural Science. The Gifford Lectures delivered in the University of Aberdeen in 1921 and 1922. By E. W. HOBSON. The Macmillan Company, 1923. xvi + 510 pages.

THE purpose of this book is to set forth and maintain by cogent argument the author's theory of the true character of natural science and by means of a strict delineation of this domain of knowledge "to vindicate the perfect freedom of religious and philosophical thought from any fear of destructive interference from the side of natural science, subject to the sole condition that no encroachment is made upon the autonomy of natural science in its own proper domain." In its implications concerning the problem of forming a general philosophy of life and the world these lectures take their place with a body of literature which has recently grown up and which has shown the rise among scientists of a saner attitude towards the place and importance of natural science in the construction of our total view of phenomena and life and character. It affords further evidence of the growing tendency to recognize and emphasize the limitations of natural science as regards certain fundamental problems of thought and philosophy not

[1] Trans. Acad. Sci. St. Louis, XX, 5, p. 67, 1911.
[2] Bull. Illinois State Lab. Nat. Hist., III, p. 385, 1892.

lying strictly within its domain. In recent years this movement has been gaining moment in a remarkable way which could hardly have been predicted ten years ago.

In order to understand properly the bearing of the author's thesis it is necessary to have in mind the exact meaning which he attributes to the term natural science. This term, he says, "is generally restricted to denote the group of those special sciences which concern themselves with the study of what we call physical phenomena, including the cases in which the phenomena are connected with living organisms." And he adds further: "In the somewhat narrow sense in which I shall employ the term, natural science excludes any direct consideration of the mental or psychical facts in living organisms from its purview." He thus restricts the term natural science to the phenomena of the apsychical physical world.

On account of the methods which he employs the conclusions of the scientist are strictly limited to a finite portion of time and a finite portion of space. They can not comprehend at once the whole of reality, or even the totality of phenomena which are capable of investigation. The possibility of natural science depends on "the fact that there is in our percepts, that is, in what we call nature, a considerable degree of regularity in the sequences of phenomena." To what extent this uniformity of nature prevails is a matter for investigation. When science comes to deal with phenomena these are treated not as individuals but as classes; natural science does not include individuality in its domain. Neither are its theories built up in terms of the percepts of phenomena nor even in terms of classes of percepts. Its scheme is a conceptual one. "An essential characteristic of every scientific theory is that it only serves to give a conceptual description of a range of phenomena which is of a limited and circumscribed character, spatially and temporally." No scientific theory is all-embracing in its character. The deterministic schemes which are set up by science are necessarily relative and partial. "The conclusion of the whole matter seems to be that the conception that the whole world of physical phenomena, or that a finite part of that world, is theoretically capable of being represented by a unified deterministic scheme is unproved and unprovable. All that natural science has established is that tracts of phenomena can be found which are sufficiently represented for certain purposes by means of deterministic schemes."

The book opens with an introductory lecture. This is followed by three lectures in which the author sets forth his main thesis concerning the conceptual character of all scientific theory and his subsidiary thesis that natural science does not enable one to conclude to a strictly deterministic scheme for natural phenomena. In the next fourteen lectures he presents the detailed argument for his general position, analyzing this with respect to mathematics, the theory of time and space, theories of matter, dynamics, electrical theory, relativity, general biology, heredity and evolution. In the two concluding lectures he treats of the relation of natural science to general thought and to theism. The volume is a very useful one for all who have to do with such questions as are raised in it.

The view set forth by Hobson "tends to limit and circumscribe the influence which natural science will have upon the wider views of the world with which philosophy and religion concern themselves. If it be admitted that natural science, when reduced to its essential elements, is independent of any opinions which may be held as regards a reality behind phenomena, and if the notions of final causes and of efficiency [in the sense of efficient causation] be regarded as extraneous to it, it would seem to follow that the existence and the special results of natural science can not be employed in any very direct manner for the purpose of throwing light upon the nature of an assumed reality, or of exercising any decisive influence in the contest between rival views as to the nature of reality."

The conclusion is thus reached that natural science can not exercise any controlling influence upon religious and philosophical thought so long as the latter leave natural science free in its own proper domain. If one adjoins to natural science certain appropriate philosophical principles and propositions, then the two together may generate conclusions of wide reach. Some possible cases are examined in the last two lectures. But there is nothing in natural science to put a categorical negative in the way of transcendental conclusions when these are reached along other paths and are sustained by considerations which lie outside the domain of natural science.

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LABORATORY APPARATUS AND METHODS

A NEW RHYTHM APPARATUS

The instruments which have been used in experimental studies of rhythm and other time processes have, as a rule, been either too restricted in their adjustment and adaptability to varieties of patterns, or else lacking in degree of precision. As there is a wide range of usefulness in various kinds of laboratories for this type of timing device, I will describe the apparatus which has gradually developed in the Iowa psychological laboratory after experimenting with various forms of rhythm apparatus.

This rhythm apparatus is built on the principle of the piano player; *i.e.*, the pattern is cut in a stencil drawn under electric contacts which energize the time-marking instrument. The stencil is cut on a one-inch ticker tape in a continuous roll of any length by using an ordinary ticket punch and stenciling by the aid of a scale of units especially devised for the purpose, indicating halves, quarters and thirty seconds of this unit. Thus, the stencil is inexpensive, may be made of any length, and can be cut into any desirable pattern. This stencil is wound on a spool, A, Fig. 1, threaded under the guides B and C, and the contact brushes, D, E, and the end is fastened in a slit on the spool, F. This spool, F, is turned by the pulley, G, which is driven by a pulley on a phonograph. In place of the phonograph disk, an iron wheel with a pulley of suitable diameter is placed on the phonograph plate. For the study of musical rhythms this pulley should be 2 inches in diameter when G is 12 inches in diameter, in order that the phonograph may run at 78 revolutions per minute to produce the speed of 2 inches per second in the tape. In order to reduce the load and insure accuracy of the phonograph movement, it is necessary that the pulley on the phonograph shall be relatively small as compared with the pulley, G, and that the latter, together with the tape, shall operate with a minimum of friction. The spool, F, is made relatively large in order to reduce the amount of increase in speed due to accumulation of the tape in successive layers. If necessary, this error may be compensated for by the speed regulator in the phonograph. One could, of course, employ a synchronous motor for a drive, but, if kept in good condition, a phonograph motor is accurate enough for nearly all practical purposes; and, in addition to this, it is the most convenient universal timing motor that we have in the laboratory. The phonograph may stand in any part of the room, as there is no objection to a long belt.

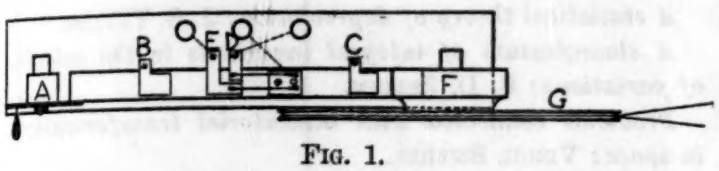

FIG. 1.

In the case of an ordinary rhythm experiment, it is necessary to have a weak and a strong sound accurately timed and alternated in patterns. This is done by having two rows of holes in the stencil, one for the accented and one for the unaccented sounds, with an electric contact brush running over each line of holes, so that when a hole passes a brush, the latter impinges upon a silver plate exposed through the hole and completes an electric circuit. For most rhythm experiments, the telegraph sounder produces a satisfactory sound. This may be energized by a storage battery or dry cells, and any desired relation of the intensity of the sound may be produced by varying the current through one of the brushes. Thus, six dry cells through one brush, and two of these through the other, makes a very satisfactory differentiation between accented and unaccented sounds.

If the apparatus is to be used for any other stimuli, the electric circuits can be used to energize these on the same principle. If more than two stimuli are needed, as many as five rows of holes may be cut on the one-inch tape; and if more than that is needed, a wider tape may be used. Thus, this apparatus can be made to operate any kind of acoustic, visual, or tactual stimuli for timed rhythmic or tachystoscopic stimulation.

At the present time we are using this apparatus in the measurement of the sense of rhythm (Kwalwasser, "The measurement of the sense of rhythm," ready for publication) and for training in the appreciation of rhythms. Kwalwasser has standardized a block of rhythms by the method of right and wrong cases and established norms for various conditions, so that the instrument is available at the present time in the musical laboratory for a ready measure of the sense of musical rhythm. This particular stencil has been put on a phonograph record and added to Seashore's "Measures of musical talent" (Columbia Graphophone Company, New York City).

C. E. SEASHORE

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AMERICAN MATHEMATICAL SOCIETY

THE thirteenth annual meeting of the American Mathematical Society was held at Columbia University, Thursday and Friday, December 27 and 28, 1923. Dormitory accommodations were furnished by Columbia University and Barnard College, and attending members were introduced at the University Faculty Club. At the dinner on Thursday, at which about 75 members were present, Professor J. L. Coolidge spoke on the progress of the Endowment Fund.

The attendance at this meeting included 95 members of the society. The secretary announced the election of 65 persons to membership. At the annual election, which closed on Thursday afternoon, the following trustees and officers and other members of the council were elected: *Trustees,* G. A. Bliss, W. B. Fite, Robert Henderson, R. G. D. Richardson, Oswald Veblen; *vice-presidents,* E. V. Huntington, T. H. Hildebrandt, J. H. M. Wedderburn; *secretary,* R. G. D. Richardson; *assistant secretary,* Arnold Dresden; *treasurer,* W. B. Fite; *librarian,* R. C. Archibald; *member of the editorial committee of the Bulletin,* Arnold Dresden; *member of the editorial committee of the Transactions,* Edward Kasner; *members of the council,* H. W.

Tyler, J. L. Coolidge, Harry Bateman, G. A. Bliss, Solomon Lefschetz, C. L. E. Moore, Anna J. Pell.

The total membership in the society is now 1,301, including 83 life members. The report of the treasurer shows a balance of $9,638.78, exclusive of special funds; of this, $5,726.91 is reserved to secure the life memberships. Sales of the society's publications during the year amounted to $3,570.03.

The society's library now contains 6,546 volumes.

At the session on Friday morning, a paper was read, at the request of the program committee, by Professor Virgil Snyder, on "Problems connected with involutorial transformations in space."

At the same session was made the first award of the Bôcher Memorial Prize, founded in honor of the late Professor Maxime Bôcher. The prize was awarded to Professor G. D. Birkhoff, for his memoir, "Dynamical systems with two degrees of freedom," published in Volume 18 of the *Transactions of the American Mathematical Society*. The regulations governing the second award in 1924 and the third in 1928 were announced.

Professor H. F. Blichfeldt was selected as a representative of the society on the National Research Council. On account of the approach of the International Mathematical Congress to be held in Toronto during the summer of 1924, four additional representatives of the society were added to the American Section of the International Mathematical Union, namely, Professors A. B. Coble, Arnold Dresden, L. E. Dickson and Virgil Snyder.

Dean H. L. Hodgkins and Professor R. G. D. Richardson were appointed to represent the society on the council of the American Association for the Advancement of Science for the year 1924.

The following papers were read at this meeting:

The analytic functions defined by a certain functional differential equation: W. B. FITE.

The field equations of relativity as integrability conditions: K. W. LAMSON.

Characterization of spaces of constant curvature by the arrangement of their geodesies: JESSE DOUGLAS.

The non-linearity of Maxwell's equations in general relativity theory: G. Y. RAINICH.

A simple proof of Lüroth's theorem: J. L. COOLIDGE.

Representation of three-element algebras: B. A. BERNSTEIN.

On the expansion of analytic functions in series of polynomials: J. L. WALSH.

A new set of postulates for betweenness, with proof of complete independence: E. V. HUNTINGTON.

A new set of completely independent postulates for cyclic order: E. V. HUNTINGTON.

Representations of integers in certain quadratic forms in 2, 3, 4, 5 indeterminates and allied class number relations: E. T. BELL.

On Pellet's theorem concerning the roots of an algebraic equation: J. L. WALSH.

The mth derivative of a function of a function; calculus of mth derivatives: E. L. POST.

Invariant directions in the theory of surfaces: W. C. GRAUSTEIN.

A property of the curvature of the line of intersection of two surfaces: D. K. KAZARINOFF.

Simultaneous algebraic equations: LOUIS WEISNER.

On the types of monoidal involutions: VIRGIL SNYDER.

On the zeros of the functions of the parabolic cylinder: EINAR HILLE.

Geodesic families and their generalizations: EDWARD KASNER.

A statistical theory of depreciation: J. S. TAYLOR.

A classification of integral invariants in the calculus of variations: S. D. ZELDIN.

Problems connected with involutorial transformations in space: VIRGIL SNYDER.

Some theorems on trajectories in V_n: JOSEPH LIPKA.

On irreversible dynamical systems under a zero force: JOSEPH LIPKA.

Relations between different types of critical points of a real analytic function of n real variables: MARSTON MORSE.

The general theory of the linear q-difference equation: C. R. ADAMS.

The invariants of forms under the total group G_n modulo 2: O. E. GLENN.

On associated forms in the theory of formal modular covariants: OLIVE C. HAZLETT.

Intermediate curvatures in a Riemann space: EDWARD KASNER.

A proof of Cauchy's integral theorem for any rectifiable boundary: G. A. PFEIFFER.

A generalization of the calculus of finite differences to include the differential calculus: J. P. BALLANTINE.

A postulational introduction to the positive integers: J. P. BALLANTINE.

A note on the theory of testimony: J. S. TAYLOR.

The determination of how much one would be justified in expending to extend the life and multiply the value of an article: C. H. FORSYTH.

A contribution to the theory of interpolation: NORBERT WIENER.

The numerical integration of differential equations: L. R. FORD.

Invariant functionals of closed plane curves under one-parameter groups of transformations of the plane: A. D. MICHAL.

Note on Dirichlet series with complex exponents: J. F. RITT.

Integration in certain n-dimensional fields with the aid of a general discontinuity factor: E. L. DODD.

The next meeting of the American Mathematical Society will be held in New York City on March 1, preceded (on the evening of February 29) by the first Josiah Willard Gibbs Lecture, which will be delivered by Professor M. I. Pupin in the Engineering Societies' Building. Meetings will also be held in Chicago on April 18–19, and at New York on May 3.

R. G. D. RICHARDSON,
Secretary